PROJECT FACT SHEET

CONTRACT TITLE: Wettability Alteration of Porous Media to Gas-Wetting for Improving productivity and Injectivity in Gas-Liquid Flows

ID NUMBER: DE-FC26-00BC15306

B&R CODE: AC1005000

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PROJECT SITE
CITY: Palo Alto **STATE:** CA
CITY: **STATE:**
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CONTRACT PERFORMANCE PERIOD:
9/21/2000 to 8/31/2003

PROGRAM: Exploration & Production
RESEARCH AREA:
PRODUCT LINE: ADIS

CO-PARTICIPANTS:

PERFORMER:	**CITY:**	**STATE:**	**CD:**
PERFORMER:	**CITY:**	**STATE:**	**CD:**
PERFORMER:	**CITY:**	**STATE:**	**CD:**
PERFORMER:	**CITY:**	**STATE:**	**CD:**

FUNDING (1000'S)	DOE	CONTRACTOR	TOTAL
PRIOR FISCAL YRS	360	117	477
FY 2002 CURRENT OBLIGATIONS	238	33	271
FUTURE FUNDS	0	0	0
TOTAL EST'D FUNDS	598	150	748

OBJECTIVE: Treat reservoir rock surfaces of a gas well with special polymers that will prevent precipitation of liquid films that clog rock pores and promote the free flow of gas to the well head.

PROJECT DESCRIPTION:

Background: In some gas condensate reservoirs, due to liquid dropout around the wellbore, gas well deliverability drops sharply as the pressure decreases below the dewpoint pressure. The decrease in gas well deliverability may occur even at high pressures (above 5000 psi). Various suggestions have been made to alleviate the problem including, 1) fluid injection to vaporize the condensate around the wellbore, 2) hydraulic fracturing, and 3) reduction of gas-condensate liquid interfacial tension by chemical injection. All these method are temporary and require a frequency which may not be economical. We suggest an alternative by changing the wettability around the wellbore from liquid-wetting to intermediate gas-wetting.

Work to be Performed: : In order to alter the wettability from liquid wetting to intermediate gas-wetting, we propose a research work with three tasks. Task I consists of relative permeability measurements before and after wettability alteration. Task II includes theoretical studies related to molecular-level theory of preferential gas-wetting and the search for suitable chemicals. Task III is intended for field implementation of the results from Task I and II. A brief description of the three tasks follows.

Task I "Relative Permeability Measurements" In Task I, we will measure primarily the imbibition gas-oil, and gas-water relative permeabilities in both Berea sandstone and chalk samples with and without chemical treatment. In the chemical treatment, special polymers were synthesized by 3M Corporation for this project. The work will include relative permeability measurements with varying values of initial water saturation. For each set of measurements the velocities will be varied to study the influence of viscous forces. Since relative permeabilities have not yet been reported in the literature for the intermediate gas-wetting, we plan to perform a comprehensive set of experiments.

Task II "Theoretical Studies Related to Preferential Gas-Wetting" Theoretical studies from the point of view of surface forces are likely to provide insight into the preferential gas-wetting process. The surface forces act on distances from the solid surface of the order of 100 nm, much more than the corresponding distance of the chemical bonds. The surface force interactions are accompanied by disjoining pressure in the thin liquid films on solid substrates. Various studies in the past have shown that the surface forces could be of: 1- van der Waals intermolecular forces, 2) electrostatic interaction between charged interfaces, 3) structural forces, 4) steric interactions, etc.

In this task, we plan to study all types of surface as well as the transition from long range to short range forces. From such studies, the effect of various parameters including temperature on intermediate gas-wetting can be found.

Task III "Field Implementation" In the second year of the project, one or two candidate reservoirs will be identified for field implementation of the idea. As soon as a field is selected, rocks and fluids from the reservoir will be used in laboratory measurements.

PROJECT STATUS:

Current Work: : In the first year of the project, we have been very active in Task I, and Task II. Extensive sets of gas and liquid phase relative permeabilities have been measured using unaltered and altered wettability states of two different rocks. We have used nC10 and nC14 liquids as the oil phase and air as the gas phase. Brine has also been used as the aqueous phase. An extensive set of gas-liquid relative permeabilities have been measured. In some of the work, water in the form of initial water saturation exists to study the effect of initial water saturation. All the above measurements have been conducted at atmospheric measurements or at a pressure some 10 to 20 psi above the atmospheric pressure. A new polymer has also been tested in recent measurements. This polymer was synthesized for the project by 3M Corporation. We have made extensive measurements with the new polymer using nC10 and nC14 and the results are very good.

In the second year of the project, a new high pressure coreholder has been designed and constructed to perform measurements with actual gas condensates. A condensate liquid from a field in Texas has been received and we have used it for imbibition testing. The results show that our surface treatment is very effective for a real condensate.

In Task II, we have derived a general expression for the surface free energy and the work of cluster formation in a complex fluid. The next step is to derive the expression for work of cluster formation with various functional groups.

Scheduled Milestones:

Completed the relative permeability measurements of two types of rocks with and without wettability alteration at low pressure.

Designed and constructed a state of the art coreholder for high pressure relative permeability measurements.

Accomplishments: Our major accomplishments in the first 15 months of the project are:

1 – Measurement of relative permeability for treated rock (intermediate-gas-wetting state) with and without initial water saturation. These measurements show that initial water saturation enhances the alteration of wettability to intermediate gas-wetting.

2 – Data demonstrating that when a rock's wettability is altered to intermediate gas wetting it can transport 5 to 8 times more liquid for a given pressure drop.

3 – Data demonstrating that our special polymer causes liquid to flow freely in porous media.

TECHNOLOGY TRANSFER:

Technology/Information Transfer: In addition to two presentations at the 2001 RERI workshop (May 3 and 4)to oil company members of the JIP, two papers have been written on the subject of relative permeability modification. An invited presentation will also be made at the 2002 Gordon Research Conference in NH.

1. Tang, T and Firoozabadi, A.: "Relative Permeability Modification in Gas-Liquid Systems Through Wettability Alteration to Intermediate Gas-Wetting," SPE Reservoir Evaluation and Engineering (in Review).

2. Tang, T. and Firoozabadi, A.: "Wettability Alteration to Intermediate Gas-Wetting in Porous Media at Elevated Pressures," Transport in Porous Media (in Review).

Public Relations:

Updated By: **Debbie Rowland** Date: **1/11/2002**